Late Triassic (Rhaetian) conodonts and ichthyoliths from Chile

Sansom, Ivan

DOI:
10.1017/S0016756800003757

Citation for published version (Harvard):
Sansom, I 2000, 'Late Triassic (Rhaetian) conodonts and ichthyoliths from Chile', *Geological Magazine*, vol. 137, no. 2, pp. 129-135. https://doi.org/10.1017/S0016756800003757

Geol. Mag. **137** (2), 2000, pp. 129–135. Printed in the United Kingdom © 2000 Cambridge University Press

Late Triassic (Rhaetian) conodonts and ichthyoliths from Chile

IVAN J. SANSOM*

School of Earth Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK

(*Received* 1 February 1999; *accepted* 2 November 1999)

Abstract – The Late Triassic of the back arc Domeyko Basin, Chile is characterized by the onset of marine sedimentation that persisted throughout the rest of the Mesozoic. Carbonate bulk samples from the Punta del Viento Limestone Formation have yielded a numerically small, but apparently widespread, conodont fauna including *Epigondolella mosheri*, *Epigondolella englandi* and *Neogondolella steinbergensis*. These specimens indicate a Rhaetian (*Epigondolella mosheri* conodont Biozone roughly equivalent to the *Paracochloceras amoenum* ammonoid Biozone) age for this unit. Their recovery represents the first record of conodonts from Chile, and also indicates a considerable potential for use in correlating sequence stratigraphic events within the Mesozoic Marginal Sea in Colombia, Peru and Chile.

1. Introduction

To complement a detailed sedimentological study of the Triassic of the Cordillera de Domeyko (Fig. 1), Chile (F. McKie, unpub. Ph.D. thesis, Univ. Birmingham, 1996), a number of carbonate bulk samples were processed for phosphatic microfossils. Seventeen samples from four localities were found to contain a mixture of biostratigraphically significant conodonts and ichthyoliths, together with an invertebrate microfossil fauna, including echinoid spines and ostracode carapaces.

The fossils described herein represent the first record of conodonts from Chile, and the only record of Triassic conodonts in South America outside of central Peru (Maeda *et al.* 1984; Orchard, 1994). Although they are few in number, conodonts were recovered throughout much of the Late Triassic Punta del Viento Limestone Formation within the Mesozoic Domeyko Basin, and include platform elements of *Epigondolella mosheri* (Kozur & Mostler, 1971), *Epigondolella englandi* Orchard 1991 and *Neogondolella steinbergensis* (Mosher, 1968). Their presence allows an assignment of this unit to the *Epigondolella mosheri* conodont Biozone (see Orchard & Tozer, 1997), broadly equivalent to the *Paracochloceras amoenum* ammonoid Biozone (Fig. 3) of the Rhaetian (*sensu* Dagys, 1988; Dagys & Dagys, 1994).

2. Geological setting and locality details

The Domeyko Basin (roughly equivalent to the Profeta Basin of Suárez & Bell (1992)) has recently been subjected to a sequence stratigraphic analysis by Ardill *et al.* (1998). With an origin as a transtensional

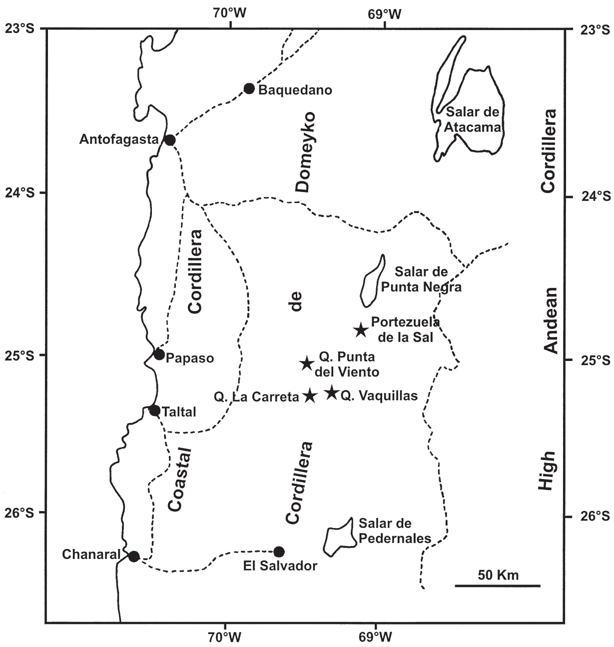

Figure 1. Locality map showing the conodont-bearing sections (stars).

rift basin, orientated roughly north–south during the Late Permian, basin fill was initially characterized by continental siliciclastic and volcanic rocks, with occasional marine incursions evident throughout much of the pre-Rhaetian succession.

All sedimentary indicators in the Domeyko Basin suggest that flooding was from the open ocean to the south (Prinz, Wilkie & Hillebrandt, 1994). This occurred during the Triassic, prior to the development of the Rhaetian Punta del Viento Limestone Formation. The transgression has been interpreted as regional in its extent (Hallam, 1991). Ardill *et al.*

* E-mail: I.J.Sansom@bham.ac.uk

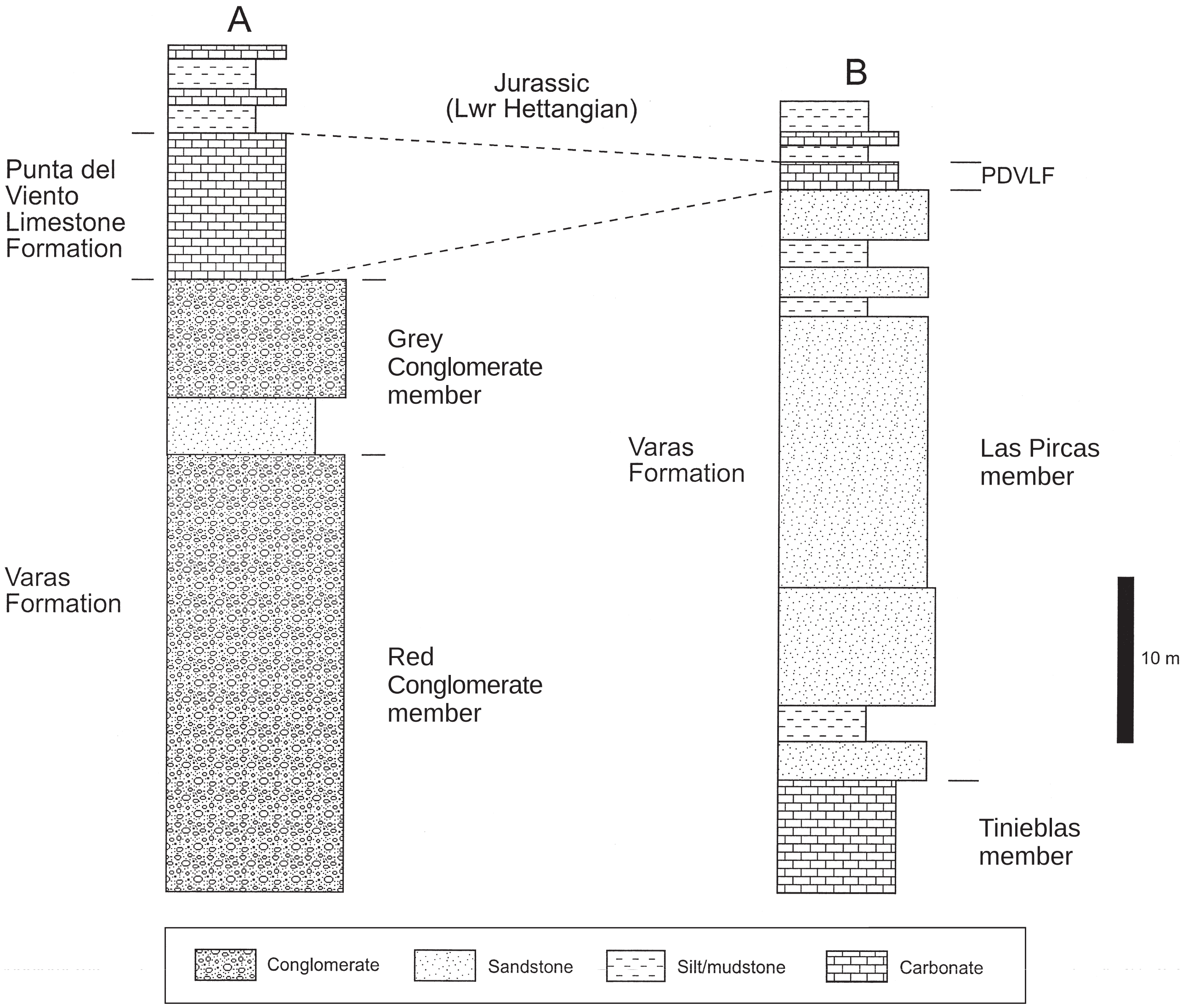

Figure 2. Schematic logs showing the putative correlation between the conodont-bearing Punta del Viento Limestone Formation (PDVLF) at Quebrada Punta del Viento (A) and the basinal section at Quebrada Vaquillas (B). All samples that have yielded conodonts come from within the Punta del Viento Limestone Formation.

(1998) placed the onset of marine conditions at the base of the Norian, although they provide no supporting data to say how they arrived at such a conclusion. Their Late Triassic–Sinemurian transgressive systems tract appears to reach its maximum during the earliest Hettangian, represented in Quebrada Punta del Viento and Quebrada Vaquillas by thinly bedded limestones, calcarenites, sandstones and mudstones from which psiloceratid ammonites have been reported by Hillebrandt (1990). Following this transgressive event, open marine conditions became established throughout much of the basin until Oxfordian times, which are characterized by a marked regional regression. Post-Oxfordian restricted lagoonal limestones and evaporites dominate all but the extreme south of the basin.

McKie (F. McKie, unpub. Ph.D. thesis, Univ. Birmingham, 1996) erected lithostratigraphic schemes for the Triassic of Quebrada Punta del Viento, Quebrada Vaquillas and Aquada de Varas, and was able to establish a degree of correlation across the basin. The bulk of the presumed Triassic basin fill is considered to represent the Varas Formation, including interbedded lavas, epiclastic rocks, conglomerates and finer grained siliciclastic rocks.

The Varas Formation at Quebrada Punta del Viento and Quebrada Vaquillas is conformably overlain by the Punta del Viento Limestone Formation (Fig. 2). The presence of sporadic shelly horizons, and ?bryozoan fragments in the Red Conglomerate member of the Varas Formation, suggest that there were occasional marine incursions prior to the deposition of the Punta del Viento Limestone Formation. At Quebrada Punta del Viento, the Punta del Viento Limestone Formation is at least 25 m thick, and consists of packstones, wackestones and mudstones, and represents the first period of sustained marine conditions within this part of the basin.

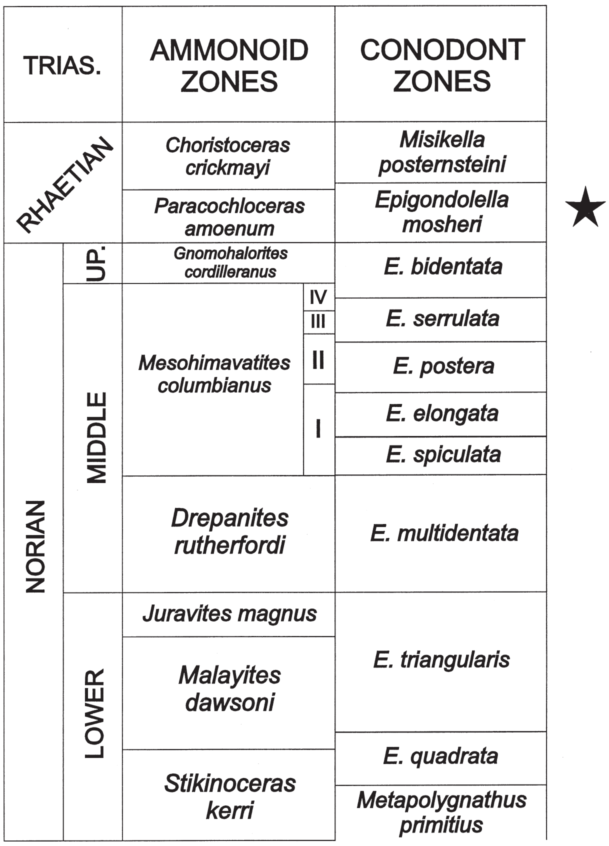

Figure 3. Biostratigraphic zonation of the Norian and Rhaetian, based upon Canadian sequences (Orchard & Tozer, 1997), showing the temporal position of the Punta del Viento Limestone Formation (starred).

At Quebrada Vaquillas, the Varas Formation is divided into a basinal facies and an infaulted basin marginal facies. The lower part of the basinal facies (Fig. 2) comprises more than 45 m of lower shoreface (Barranco member) and subtidal–intertidal–supratidal transitions, with occasional lagoonal stromatolitic and thrombolitic microbialites (Tinieblas member). These are overlain by at least 95 m of poorly exposed sands and silts (Las Pircas member), with a prominent 2.5 m thick wackestone/packstone unit at the top, which can be correlated with the Punta del Viento Limestone Formation, and represents a slight topographic high or the quiescence of detrital input.

Chong & Hillebrandt (1985) and Hillebrandt (1990) have reported an upper Triassic macrofauna from the Punta del Viento Limestone Formation at Quebrada Punta del Viento. They list corals, brachiopods, pelecypods and gastropods of Late Triassic age (Hillebrandt, 1990, p. 38), although they do not identify the taxa recovered.

3. Material and methods

Bulk carbonate samples were collected from the Punta del Viento Limestone Formation principally from logged sections within Quebrada Punta del Viento (69°15′ W, 25°06′ S; Fig. 1) and Quebrada Vaquillas (69°17′ W, 25°19′ S; Fig. 1). Spot samples have also been processed from Quebrada La Carreta and Portezuela de la Sal (see Hillebrandt (1990) for locality details). The biostratigraphically important *Epigondolella mosheri* was recovered from all of these localities, as were fish scales and teeth. Elements of *Epigondolella englandi* and *Neogondolella steinbergensis* were found in residues from Quebrada Vaquillas. A small number of highly fragmentary ramiform conodonts were also present in these residues, their poor preservation precluding any further taxonomic assignment. Ichthyoliths were only identifiable to generic level, and are included in *Glabisubcorona* sp. from Quebrada Punta del Viento.

All illustrated specimens with the prefix BU are deposited in the Lapworth Museum, University of Birmingham.

4. Systematic palaeontology

Class CONODONTA Eichenberg, 1930
Sensu Clark, 1981
Order OZARKODINIDA Dzik, 1976
Family GONDOLELLIDAE Lindström, 1970
Genus *Epigondolella* Mosher, 1968
Epigondolella mosheri (Kozur & Mostler, 1971)
Figure 4c–h, l–q

*1968 *Epigondolella bidentata* Mosher, p. 936, pl. 118, fig. 36.
1971 *Tardogondolella mosheri* Kozur & Mostler, p. 15.
1991 *Epigondolella mosheri* (Kozur & Mostler); Beyers & Orchard, pl. 5, fig. 21.
1991 *Epigondolella mosheri* Kozur & Mostler; Orchard, p. 309–10, pl. 4, figs 11, 13, 14.
1994 *Epigondolella mosheri* Kozur & Mostler; Orchard, p. 207, pl. 1, figs 1–12.

Holotype. USNM 159234, Mosher, 1968, pl. 118, fig. 36.

Diagnosis. See Orchard (1994), p. 207.

Remarks. Orchard (1994) re-assessed *E. mosheri*, recognizing two morphotypes. Morphotype A corresponds to the type specimen, and is represented by slender, bidentate elements with an elongate platform. Orchard (1991, 1994) noted that this type of element has often been assigned to other members of the *E. bidentata* group, and that they may represent juvenile forms. Morphotype B was erected to include specimens with broader platforms and several nodes along the posterior platform margin; this morphotype seems to be representative of more mature specimens. Both morphotypes have been encountered in the Chilean samples.

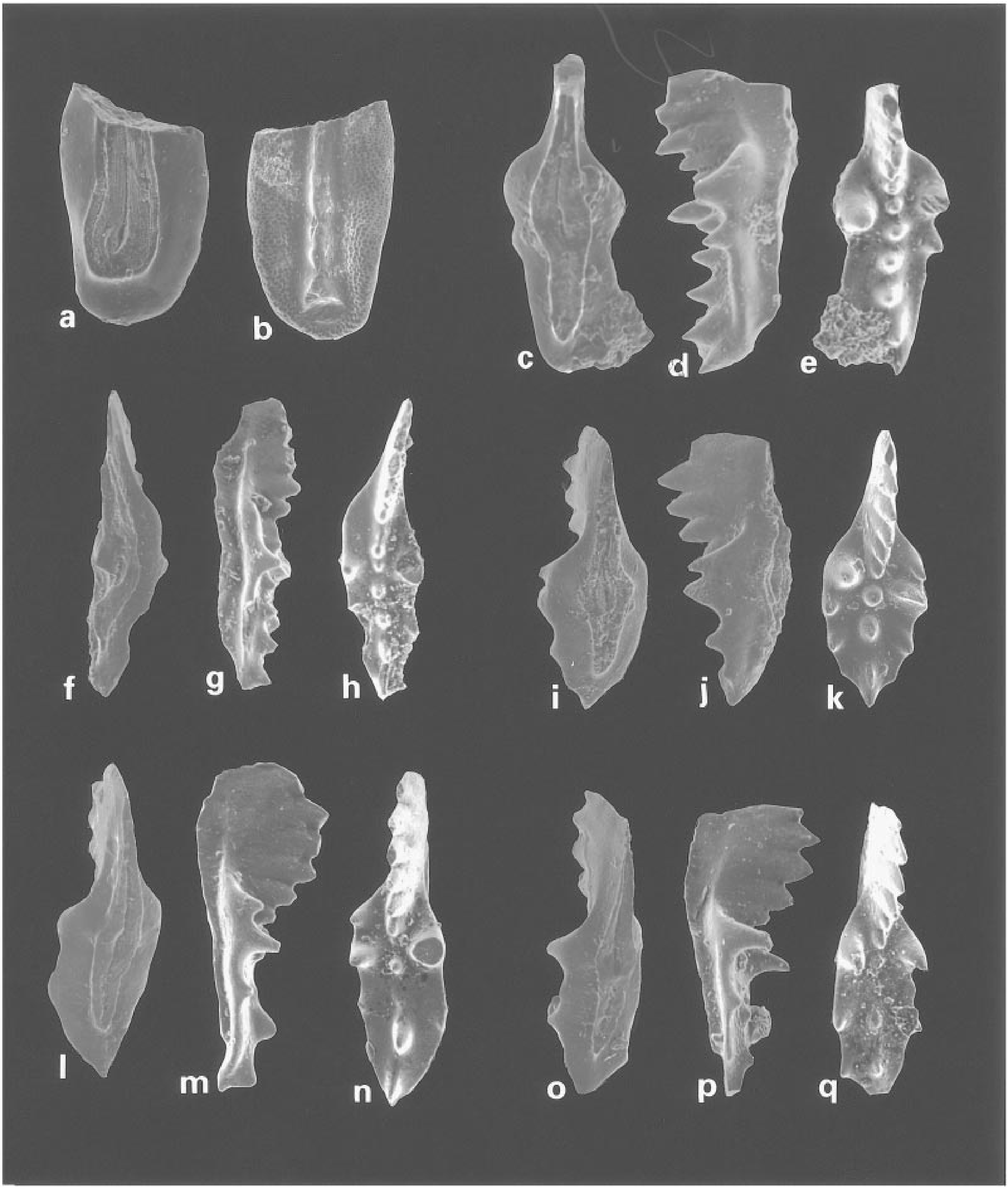

Figure 4. Conodonts from the Punta del Viento Limestone, Rhaetian, Cordillera de Domeyko, Chile. (a, b) *Neogondolella steinbergensis* (Quebrada Vaquillas, BU 2685) in basal (a) and oral (b) views, × 90. (c, d, e) *Epigondolella mosheri* (Quebrada Vaquillas, BU 2686) in basal (c), lateral (d) and oral (e) views, × 90. (f, g, h) *Epigondolella mosheri* (Quebrada Punta del Viento, BU 2688) in basal (f), lateral (g) and oral (h) views, × 90. (i, j, k) *Epigondolella englandi* (Quebrada Vaquillas, BU 2687) in basal (i), lateral (j) and oral (k) views, × 80. (l, m, n) *Epigondolella mosheri* (Quebrada Punta del Viento, BU 2689) in basal (l), lateral (m) and oral (n) views, × 90. (o, p, q) *Epigondolella mosheri* (Quebrada Punta del Viento, BU 2690) in basal (o), lateral (p) and oral (q) views, × 90.

Material. Sixteen specimens from Quebrada Vaquillas; twenty-one specimens from Quebrada Punta del Viento; seven specimens from Portezuela de la Sal; two specimens from Quebrada La Carreta.

Epigondolella englandi Orchard, 1991
Figure 4i–k

*1991 *Epigondolella englandi* Orchard, p. 309, pl. 5, figs 9, 11, 13, 19–20.

Holotype. GSC 95290, Orchard, 1991, pl. 5, figs 11, 13, 19.

Diagnosis. See Orchard (1991), p. 309.

Remarks. *E. englandi* is readily distinguished from other members of the *E. bidentata* group by the teardrop shape of the reduced platform. In comparison with the type specimens from the Yukon Territory, the specimen herein has more nodes on the posterior margin of the platform. This feature may strengthen the phylogenetic connection between *E. englandi* and the older *E. carinata* Orchard, 1991.

Material. One specimen from Quebrada Vaquillas.

Genus *Neogondolella* Bender & Stoppel, 1965
Neogondolella steinbergensis (Mosher, 1968)
Figure 4a–b

*1968 *Paragondolella navicula steinbergensis* Mosher, p. 939, pl. 117, figs 13–22.

Holotype. USNM 159197, Mosher (1968), pl. 117, figs 18, 19.

Remarks. Kozur (1990) erected the genus *Norigondolella* for *steinbergensis*. This name has yet to gain wide acceptance amongst Triassic conodont workers and *Neogondolella* is retained here.

Material. Two specimens from Quebrada Vaquillas.

Class CHONDRICHTHYES Huxley, 1880
Subclass ELASMOBRANCHII Bonaparte, 1838
Order and Family *Incertae sedis*
Genus *Glabrisubcorona* Johns *in* Johns, Barnes & Orchard, 1997
Glabrisubcorona sp.
Figure 5a–d

Description. (1) Trunk scales. The crown is roughly rhombic in shape, with a narrow mesial platform forming a prominent anterior protrusion. A pair of shallow lateral ridges are found towards the external margin of the lateral wings. The posterior margin is slightly abraded, but it appears that the principal cusp is broad, and the shallow lateral ridges terminate on the posterior margin without the development of lateral cusps. The scale base lies anteriorly, and is concave and tetrapetaloid; the subcrown is unornamented. (2) Head scales. The scales are rhombic, with a presumably subcentral pedicle. The crown margins are crenulated with alternating projections and concave indentations.

Remarks. Chondrichthyans are known to be covered in a wide variety of scales, with rounded or rhombic scales with subcentral pedicles characteristic of the head region and anteriorly offset pedicles found on trunk and fin scales (see Reif (1985) and Yano, Goto & Yabumoto (1997) for examples). These differences can be readily recognized in *Glabisubcorona* sp., even on

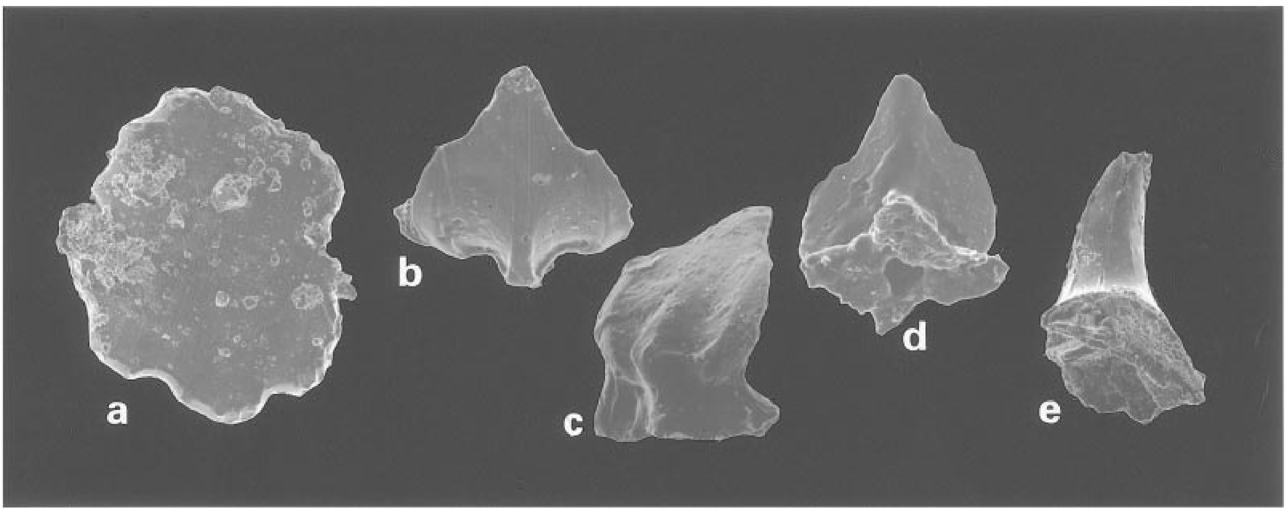

Figure 5. Ichthyoliths from the Punta del Viento Limestone Formation, Rhaetian, Cordillera de Domeyko, Chile. (a) Head scale of *Glabisubcorona* sp. (Quebrada Punta del Viento, BU 2691), × 45. (b, c, d) Trunk scale of *Glabisubcorona* sp. (Quebrada Punta del Viento, BU 2692) in upper (b), antero-lateral (c) and basal (d) views, × 110. (e) Indeterminate fish tooth (Quebrada Vaquillas, BU 2693), × 45.

the limited number of specimens from the Domeyko Basin. It is notable that *Glabisubcorona* sp. follows the morphological trends, including the presence of a tetrapetaloid base in the trunk scales and the absence of subcrown ornament, identified in Middle and Late Triassic chondrichthyan scales by Johns *et al*. (1997).

Material. Four head scales and one trunk scale from Quebrada Punta del Viento.

5. Conclusions

The widespread distribution of shallow marine limestones within the upper Triassic of the Domeyko Basin led Ardill *et al*. (1998) to suggest that they represented a substantial marine transgression. The absence of biostratigraphically useful fossils that might allow correlation of the disparate sections has made this proposal difficult to test. Ammonites and other macrofossils have been reported from a limited number of localities (Hillebrandt, 1990), but it is evident from this preliminary study that conodonts and ichthyoliths have greater potential as correlative tools within the Rhaetian carbonate facies of Chile, and ultimately might provide high-resolution correlation of the limestone units.

That *Epigondolella mosheri* also occurs in the Chambará Formation in the lower Pucará Group of west central Peru, some 2000 km to the north of the Domeyko Basin at the present time, indicates the potential for developing a conodont biostratigraphic framework for lower Mesozoic rocks throughout central South America. This, allied to a detailed sequence stratigraphic analysis, should provide greater understanding of the geological evolution of the western margin of Gondwana. The specimens referred to *Epigondolella bidentata* Mosher by Maeda *et al*. (1984) from the Chambará Formation of the Cerro de Pasco area of central Peru may be indicative of the slightly older *Gnomohalorites cordilleranus* ammonoid Zone (Orchard, 1994), although these specimens require further examination as they are only illustrated in lateral view.

Acknowledgements. The samples were collected and some initially processed by Fiona McKie (formerly of the University of Birmingham). The author is grateful to her for allowing access to the material, and for subsequent discussions regarding the relevance of the microfaunas to the stratigraphy of the Cordillera de Domeyko. Mike Orchard (GSC, Vancouver) provided considerable help with the conodont biostratigraphy and with various drafts of the manuscript, whilst Paul Smith, Alan Thomas and Peter Turner (all University of Birmingham) are thanked for encouragement and advice during this study. Tony Hallam (Birmingham) collected the sample from Quebrada La Carreta, which was processed by Andy Swift (University of Leicester), and is thanked for discussions on Late Triassic sea levels. Howard Armstrong's (University of Durham) referee's comments considerably improved the manuscript. Finally, Guillermo Chong Diaz (Antofagasta) is warmly thanked for his many discussions on the geology of the Cordillera de Domeyko.

References

Ardill, J., Flint, S., Chong, G. & Wilkie, H. 1998. Sequence stratigraphy of the Mesozoic Domeyko Basin, Northern Chile. *Journal of the Geological Society, London* **155**, 71–88.

Bender, H. & Stoppel, D. 1965. Perm-Conodonten. *Geologisches Jahrbuch* **82**, 331–64.

Beyers, J. M. & Orchard, M. J. 1991. Upper Permian and Triassic conodont faunas from the type area of the Cache Creek Complex, south-central British Columbia, Canada. *Geological Survey of Canada, Bulletin* **417**, 269–97.

Bonaparte, C. L. J. L. 1838. Synopsis vertebratorum systematis. *Nuovi Annali delle Scienze Naturali* **2**, 105–33.

Chong, D. G. & Hillebrandt, A. 1985. El Triásico Preandino de Chile entre los 23°30′ y 26°00′ de Lat. Sur. *4th Congreso Geologico Chileno, Antofagasta* **1**, 162–210.

Clark, D. L. 1981. Classification. In *Treatise on Invertebrate Paleontology, Part W, Supplement 2, Conodonta* (ed. R. A. Robison), pp. 102–3. Lawrence, Kansas: Geological Society of America and University of Kansas Press.

Dagys, A. 1988. An alternative interpretation of the Rhaetian. *Albertiana* **7**, 4–6.

Dagys, A. S. & Dagys, A. A. 1994. Global correlation of the terminal Triassic. *Memoires de Geologie (Lausanne)* **22**, 25–34.

Dzik, J. 1976. Remarks on the evolution of Ordovician conodonts. *Acta Palaeontologica Polonica* **21**, 395–455.

Eichenberg, W. 1930. Conodonten aus dem Culm des Harzes. *Paläontologische Zeitschrift* **12**, 177–82.

Hallam, A. 1991. Relative importance of regional tectonics and eustacy for the Mesozoic of the Andes. In *Sedimentation, Tectonics and Eustasy: Sea-Level Changes at Active Margins* (ed. D. I. M. Macdonald), pp. 189–200. Oxford: International Association of Sedimentologists, Special Publication 12.

Hillebrandt, A. 1990. The Triassic/Jurassic boundary in northern Chile. *Meeting on the Triassic/Jurassic boundary, Lyon. Institute Catolica, Cahiers Series Scientifique* **3**, 27–53.

Huxley, T. H. 1880. On the applications of the laws of evolution to the arrangement of the Vertebrata and more particularly of the Mammalia. *Proceedings of the Zoological Society of London* **1880**, 649–62.

Johns, M. J., Barnes, C. R. & Orchard, M. J. 1997. Taxonomy and biostratigraphy of Middle and Late Triassic elasmobranch ichthyoliths from northeastern British Columbia. *Geological Survey of Canada, Bulletin* **502**, 1–235.

Kozur, H. 1990. *Norigondolella* n. gen., eine neue obertriassische Conodontengattung. *Paläontologische Zeitschrift* **64**, 125–32.

Kozur, H. & Mostler, H. 1971. Probleme der Conodontenforschung in der Trias. *Geologische und Paläontologische Mitteilungen, Innsbruck* **1**, 1–19.

Lindström, M. 1970. A suprageneric taxonomy of the conodonts. *Lethaia* **3**, 427–45.

Maeda, S., Brado, E. B., Arnao, B. M., Zavala, C. R. & Kawabe, T. 1984. *On Some Late Triassic Molluscs and Conodonts from the Cerro de Pasco Area, Central Peru.*

Chiba, Japan: Chiba University, Faculty of Science, Department of Earth Sciences, 16 pp.

MOSHER, L. C. 1968. Triassic conodonts from western North America and Europe and their correlation. *Journal of Paleontology* **42**, 895–946.

ORCHARD, M. J. 1991. Upper Triassic conodont biochronology and new index species from the Canadian Cordillera. *Geological Survey of Canada, Bulletin* **417**, 299–335.

ORCHARD, M. J. 1994. Late Triassic (Norian) conodonts from Peru. *Palaeontographica, Abteilung A* **233**, 203–8.

ORCHARD, M. J. & TOZER, E. T. 1997. Triassic conodont biochronology and intercalibration with the Canadian ammonoid sequence. *Albertiana* **20**, 33–44.

PRINZ, P., WILKE, H. & HILLEBRANDT, A. 1994. Sediment accumulation and subsidence history in the Mesozoic marginal basin of northern Chile. In *Tectonics of the Southern Central Andes* (eds K. J. Reutter, E. Scheuber and P. J. Wigger), pp. 219–32. Berlin: Springer-Verlag.

REIF, W.-E. 1985. Squamation and ecology of sharks. *Courier Forschungsinstitut Senckenberg* **78**, 1–255.

SUÁREZ, M. & BELL, C. M. 1992. Triassic rift-related sedimentary basins in northern Chile (24°–29° S). *Journal of South American Earth Sciences* **6**, 109–21.

YANO, K., GOTO, M. & YABUMOTO, Y. 1997. Dermal and mucous denticles of a female Megamouth shark, *Megachasma pelagios*, from Hakata Bay, Japan. In *Biology of the Megamouth Shark* (eds K. Yano, J. F. Morrissey, Y. Yabumoto and K. Nakaya), pp. 77–91. Tokai, Japan: Tokai University Press.